Method for producing paper or board and a product produced by the method

The present invention relates to a method according to the preamble of claim 1 for manufacturing paper and paperboard products, the method comprising the steps of monitoring web formation during the manufacturing process and surface sizing the web at least on one side. The method also allows the control of curl in the manufactured product.

The invention also relates to a product manufactured by virtue of the method.

In paper manufacture, as factors of increasingly higher importance have arisen a precise adaptation of the properties of the product being manufactured to buyer's quality requirements and optimization of energy and raw material consumption during product manufacture. Various paper grades are produced for a broad spectrum of applications, whereby the end user requirements may differ widely. Examples of such products are copier and printer paper grades. Among other qualities, the qualities of these grades should include low linting and sufficient stiffness to make them run smoothly via the paper feed paths of copier/printer equipment. Obviously, the surface properties of the paper must be good to secure high quality of print. These properties are attained by using a base web that has a sufficiently high basis weight, is formed from high-quality fiber and additionally is surface sized. Due to these basic requirements, the price of copier paper becomes high, because a large amount of fiber is used to obtain a high basis weight and the application of a surface size loads the web with imported surplus water that must be evaporated using a lot of energy.

The function of surface sizing is to improve the surface qualities of a product, where size also improves the internal strength of the web. In order to additionally improve the internal strength of the web by sizing, the size furnish must have a high water content to make the furnish penetrate deep into the web. As a result, a high drying capacity is needed, even further accentuated by the fact that water is the more difficult to remove the deeper the penetration of water into the web. Hence, drying of surface size makes up a substantial portion of the drying capacity that must be used.

On a papermaking machine used for producing surface-sized paper grades, sheet curl can be managed today by using a twin-felted run system on the post-dryer section or, alternatively, treating the underside of the web with water and steam on single-felted runs. In a twin-felted system, symmetrical drying can be attained by proper adjustment of steam pressures on the upper and lower cylinders. Inasmuch as heat in a single-felted system is introduced to the web via one side only and evaporation can take place principally only from the same side (bottom side), the paper or paperboard web tends to billow out toward the top side. For a two-sided paper, a simple rule to remember is that curl occurs toward the side drying last. While the same rule applies to both twin-felted and single-felted runs, the effect is less pronounced on twin-felted runs.

It is an object of the present invention to provide a method suited for making paper products at lower raw material and specific energy consumption that those required in the manufacture of conventional products having similar qualities.

It is a further object of the invention to provide an embodiment of the invention suited for the control of curl of a paper or paperboard product being manufactured.

The goal of the invention is achieved by way of keeping the speed differential, or the draw, between the press section and the dryer section of the paper/paperboard making machine lower than 3 % and performing surface sizing with a size furnish wherein the proportion of size solids is at least 15 %.

More specifically, the method in accordance with the invention is characterized by what is stated in the characterizing part of claim 1.

Furthermore, the product in accordance with the invention is characterized by what is stated in the characterizing part of claim 6.

The invention offers significant benefits.

By virtue of keeping the draw between the press section and the dryer cylinders lower than 3 %, the internal bond strength (Hyugen), work-to-rupture and breaking elongation increase while web porosity decreases. As a result, surface sizing need not be used for increasing the internal bond strength of the product, but rather, size furnishes of higher solids can be used, whereby the size remains on the web surface. Thus a web structure is attained having the size layers coating the product surfaces and the base sheet acting as a middle layer in the same fashion as in a composite structure. The outcome is a very stiff product in regard to its basis weight. Such a product is well suited for use as a copier paper or, if manufactured as a paperboard grade, as a packaging cardboard. By way of keeping the s small, the tensile strength of the web remains substantially equal in both the cross-machine and machine directions. In the perpendicular direction (z-direction) to the paper surface, the breaking elongation and the work-to-rupture increase.

On the other hand, reduction of the sheet basis weight increases the internal bond strength by 10 - 20 % thus allowing a higher size solids to be used in conjunction with a lower basis weight. In a surface sized paper, there is a crosscorrelation between the sheet basis weight and the draw in the press section such that setting the draw at 1 to 2 % gives in the reduction of basis weight a more pronounced effect on the increase of internal bond strength than a draw of about 3 %. Hence, the reduced basis weight made possible by using a lower draw on the press section enhances the other benefit obtained by the lower draw.

The above discussed variables related to the strength of the base sheet, particularly the lower porosity, principally result from the fact that the reduced draw causes less debonding of the fibers in the base sheet and reduces the deformation of fibers because the tensile stress of the web is reduced at the reduced draw. Thus, the lower draw cannot cause damage to the web by tensile elongation.

However, the benefits of reduced draw can be attained only through the use of modern web speed control methods. Obviously, as the function of draw is to keep the

web tight on the rolls of the papermaking machine, it has been necessary at high web speeds and in the handling of wet web to keep the web under high tensile stress, that is, under tight draw. Among other variables, the lower draw is facilitated by improved web guidance with the help of wires and felts in combination with high-vacuum suction boxes that remove the web from the surface of the rolls.

When the draw is reduced, the machine-direction Young's modulus is lowered slightly while the cross-machine Young's modulus stays unchanged, the latter being vital particularly in the manufacture of copier paper inasmuch as the flexural stiffness especially in the cross-sheet direction is crucial to secure consistently reliable sheet infeed in the copier/printer.

By way of increasing the solids content of the surface size, the amount of water imported to the web is reduced with the immediate result that less drying capacity is needed in the process. This benefit is further accentuated by the lesser absorption of water into the web. The surface size furnish may be complemented with other additives such a brightener or pigment particles. Particularly the use of a brightener has been found advantageous. As the surface size remains on the surface of the web, the consumption of possible additives is small because no loss of additives via absorption into the base sheet takes place. Hence, more liberal use of expensive additives may be considered, too. One specific feature of brightener addition is that the method according to the invention increases the whiteness of the product, which is in contrast to the traditional belief in the art that the use of a brightener is detrimental to product whiteness. By having a distinct, sealing layer of surface size formed on the sheet surface, the product according to the invention is well suited for use in ink-jet printing and similar hardcopy processes, because the ink cannot excessively penetrate into the fibers and interfiber voids, whereby the contours of ink spots and printed patterns become sharply defined.

Control of web curl can be managed by virtue of the method according to the invention either via changing the amount of surface size application or the water content of the surface size furnish. As the starch of the surface size at high size solids forms a

layer on the base paper surface, the sized sheet acts like a layered composite structure in which the surface sized top/bottom layers serve as the shell element. This shell element gives a vital contribution to the flexural stiffness of the sheet and, thereby, to the web curl. Hence, the method according to the invention offers efficient tools to the control of web curl. In summary, the following benefits are gained:

- existing dryer sections can be run at higher web speeds,
- control of curl in the web requires no water and steam, or at least a marginal amount in regard to current practice will be sufficient, and
- runnability and production efficiency can be retained at a high level.

Moreover, control of curl can be still further essentially improved over the prior art by virtue of using different size furnishes on the two sides of the web, whereby for instance the solids of the two sides can be adjusted different from each other. The effect on absorption, however, is such that absorption on the bottom side of the web increases inasmuch a larger amount of water is applied thereon by virtue of the web curl control system.

While the paper and paperboard qualities manufactured using the method according to the invention are not generally calendered or coated, there is no hindrance to forwarding the manufactured product to such further finishing steps.

In the following, the invention is examined with the help of an exemplary embodiment. The paper grade of the example is well suited for use as copier or printer paper.

Today, copier equipment manufacturers recommend the use of a copier paper grade having a basis weight of 80 g/m^2. This recommendation aims to secure a sufficient sheet stiffness in the infeed and printing sections of copier/printer equipment. Typically, this kind of paper is surface sized using a furnish having a solids content of about 10 % and applied, e.g., 10 g/m^2 as a wet film on both sides of the web. Then, the portion of dry weight of size solids is 2 g/m^2, whereby the basis weight of the base sheet must be 78 g/m^2.

According to the invention, the internal bond strength is secured by keeping the draw between the press section and dryer section of the papermaking machine lower than 3 %, advantageously in the range 1 - 2%, whereby the internal bond strength required from the base sheet stays good. If the basis weight of the base sheet is lowered to a value of 68 - 72 g/m^2, the computational value of product stiffness reduction is 15 – 25 %. This stiffness reduction due to thinner base sheet is compensated for by using in surface sizing a furnish of 25 % solids in the dry weight of the size, whereby the product has a sufficient stiffness and at least equal surface qualities as those of a comparative product surface sized with a smaller amount of size. In this context, the dry solids of the size is defined as the proportion of the actual solids of the size in regard to the amount of water in the furnish. While the overall solids of the furnish may be increased substantially for instance when using pigment additives, at the lower end of solids content the proportion of size components in the total amount of size material and water should not be less than 15 % to avoid excessive penetration of size furnish into the interfiber voids. Advantageously, the size solids is at least 20 %, most advantageously 25 %. As a dry weight of the size layer, the total amount of applied size may be equal to the layer weight when size is applied using a furnish of less solids, but in the case that the product basis weight is precisely specified, e.g. at the above-mentioned 80 g/m^2, the amount of size may be increased. Making the product from a base sheet of 68 g/m^2 basis weight, for instance, the application of a 25 % solids size requires the size furnish to be applied by 24 g/m^2 of the wet size film on both sides of the base sheet which is a rather large amount of applied size that may preferably be implemented using even a greater amount of size solids.

The invention makes it possible to optimize the consumption of raw materials and, particularly, the product stiffness. As the size remains on the product surface, the contribution of the size layer to the product stiffness is substantial, whereby the product stiffness can be modified easier by changing the applied size weight than by using a base sheet of different basis weight. Because the surface size is not necessary to increase the internal bond strength of the base sheet, the properties of the size can be fully utilized to improve the surface qualities and stiffness of the paper product.

While the invention is particularly suited for manufacturing copier and ink-jet printer paper grades, it may also be utilized in other kinds of products specified for a good ratio of stiffness to basis weight, even in packaging cardboard grades. Furthermore, in principle it is possible to surface size the web only on one side if such a product is requested. Obviously, the surface size furnish may be prepared based on some other liquid than water, whereby the proportions of size components must be computed relative to the total volume of liquid.

In the product according to the invention, the goal is to keep the size in the coat layer of the product and the penetration into the interfiber voids must be minimal. To this end, at least 80 %, advantageously 90 %, of the total amount of applied size shall remain on the base sheet fiber layer.

The increase of solids in the surface size furnish allows the top and bottom sides of the web to be coated with the same amount of size but in different amounts solids, whereby the amounts of water applied to the two sides of the web may be varied widely. The size solids can be varied in a range as wide as 8 to 30 %. If the solids of the dried size is adjusted to 1.5 g/m^2, it means that the amount of water applied to the web is 3.5 g/m^2 minimum and 17.3 g/m^2 maximum. Obviously, the range of allowable water application is really wide. Inasmuch this difference in the amount of water applied to the two sides of web makes it possible to efficiently control the tendency of the web to curl after drying, whereby the curl of the paper web is maximally easy to manage.

Typically, on a prior-art surface-sizing press to the web is applied aqueous furnish of surface size containing water in such an amount that the solids content of a web of 70 g/m^2 basis weight falls from 97 % to about 70 %, whereby the web contains 30 g/m^2 water distributed essentially uniformly over the cross-machine direction of the web. Removal of this excess moisture content from the web requires plural dryer cylinders. If the dryer construction is based on single-felted runs, a moisture content gradient is formed when the bottom side dries first, whereby the web is subjected to

internal stresses that force the web to billow out toward its top surface.

In a situation where the amount of water imported to the web is only half of that applied conventionally, a feasible arrangement could be such that, for instance: size furnish is applied on both the top surface and the bottom surface by the same amount of 1.5 g/m^2 furnish having different solids contents so that the dry solids of the bottom side furnish is 10 % while 25 % dry solids is applied to the top side. The corresponding amounts of imported water are 13.5 g/m^2 and 3.5 g/m^2. Resultingly, the moisture content to be removed from the bottom side is more than three times greater than the moisture content evaporating from the web top side. Hence, a radical change takes place in the distribution of evaporation in a single-felted dryer group. Due to the substantially smaller amount of moisture being evaporated via the top surface, the web curl may be expected to be reduced and even change its billowing direction if the difference between the amounts of water applied to the top and bottom sides of the web is adjusted sufficiently large.

Using the above-mentioned amounts of surplus water (13.5 g/m^2 and 3.5 g/m^2) imported to the web of 70 g/m^2 basis weight discussed in the exemplary embodiment above, the solids content of the web will be 80.5 % which is substantially more than 70 % conventionally used in the art. Also the number of required dryer cylinders is reduced. For instance, on a papermaking machine having 12 cylinders in a single-felted run, the drying process is as follows: the two last cylinders of the dryer group are cooling cylinders and a surplus amount 1 g/m^2 water is imported to the web at the end of the dryer section. Now, with the provision that the amount of water imported to the web during sizing can be lowered in the fashion described in the exemplary embodiment, the reduction in the amount of imported water is about 43 % in regard to the conventional level (30 g/m^2 vs. 17 g/m^2). Hence, the number of dryer cylinders can be reduced by about 40 % as compared with the prior art.